

**Claims**

1. A frequency beamsplitter for use in the frequency basis, comprising: an asymmetric two-path interferometer, reversible down to the quantum limit, a first partially transmitting mirror to split photons into first and second paths, a time delay element to introduce a differential time delay into the second path, and a second partially transmitting mirror to mix the two paths again to form two outputs.
2. A frequency beamsplitter according to claim 1, wherein the interferometer has a frequency dependent phase shift.
3. A frequency beamsplitter according to claim 2, wherein the interferometer is a Mach-Zehnder interferometer.
4. A frequency beamsplitter according to claim 2, wherein the interferometer is a Michelson interferometer.
5. A frequency beamsplitter according to any preceding claim, wherein, additional mirrors are provided between the partially transmitting mirrors or at the output to redirect the first and second paths to provide the outputs at convenient locations.
6. A frequency beamsplitter according to any preceding claim, comprising mirrors and a time delay implemented using optical fibre structures.
7. A frequency beamsplitter according to any one of claims 1 to 5, comprising mirrors and a time delay implemented using planar waveguide structures.
8. A frequency beamsplitter according to any preceding claim, arranged to operate with single photons.
9. A radio frequency half-wave plate for use in the frequency basis, comprising a frequency beamsplitter according to any one preceding claim, to split a beam of photonic qubits encoded in different frequency modes, an acousto-optic modulator driven to receive the outputs from the frequency beamsplitter and couple the two different frequency and spatial modes of the outputs together via a phonon interaction to produce two further outputs, a frequency beamsplitter according to any preceding

claim, operating in reverse to receive the two further outputs from the acousto-optic modulator and produce a combined output.

10. A radio frequency half-wave plate according to claim 9, wherein a single  
5 frequency beamsplitter is used, operating in one direction and in reverse.